PB-217 695

DELAWARE ESTUARY COMPREHENSIVE STUDY

Public Health Service
New York

September 1963

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 217 695

Delaware Estuary Comprehensive Study

REPORT NUMBER ____

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service
Division of Water Supply and Pollution Control

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

Delaware Estuary Comprehensive Study

Report Number____

Division of Water Supply and Pollution Control
Region II , New York, New York

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

Review of Present Water Quality and Interstate Standards

of the Delaware Estuary

Interim Report from the Technical Committee

to the Policy Advisory Committee

September, 1963

SUMMARY

The following interim report was prepared at the request of the Policy Advisory Committee of the Delaware Estuary Comprehensive Study. The charge from the Committee essentially covered four specific areas which related to the existing interstate standards for control of pollution in the Delaware River Basin. These four areas are:

1) present water quality condition of the Estuary,
2) present degree of compliance with the quantitative aspects of the interstate standards,
3) effect on the quality of the river if literal compliance with the quantitative aspects of the standards were adhered to everywhere and
4) estimates of what changes must be sought in present levels of waste treatment to meet the 50% DO saturation goal set by the standards for Zone III (Pennypack Creek to the Pennsylvania-Delaware State Line.

These four points are considered in the report. The estimates that are given in each case are based on the available data and should be considered as preliminary and subject to future change. It is felt, however, that the report will prove to be a useful guide for the members of the Policy Advisory Committee.

The results can be summarized as follows:

1. Mean dissolved oxygen (DO) concentrations for the total period August-October 1962 and June-July 1963 were less than or equal to 1.0 mg/l from central Philadelphia to Marcus Hook, Pa., a distance of about 20 miles. At times, the DO is completely exhausted. The mean pH during June-August 1963 decreased continually from a level of about 7.0 at the upper end of the estuary to a level of about 6.0 at the Delaware Memorial Bridge. Highest turbidity levels were observed in the vicinity of Florence, N. J. Geometric mean coliform counts varied from a high of 260,000/100 ml around the Tacony-Palmyra Bridge to a low of 12,000/100 ml at Florence, N. J.
2. Discussions held with representatives of Pennsylvania and New Jersey indicated that administratively practically all sources were considered to be in compliance with the existing standards. Delaware has previously indicated that all sources within that state were considered to be in compliance. In some cases, data were available that indicated present per cent BOD removals less than that of the standards. While these sources were considered to be in administrative compliance by the State agency, a literal adherence was used in the analysis of the effectiveness of complete quantitative compliance with the standards.
3. In the analysis of the effectiveness of complete compliance, two municipalities and three industries in New Jersey and one industry and one municipality in Pennsylvania were used. The removal of BOD from these sources to literally comply with the standards

produced a numerical increase of at least .01 mg/l of DO in some portion of the estuary. Four other municipalities and two other industries in New Jersey were suspected to be not in compliance with the standards. However, raising the per cent BOD removal of these sources produced a response less than .01 mg/l DO.

4. A computer analysis of literal compliance by the significant sources mentioned above indicated that in general the DO response would be quite low and, considering the assumptions that were made, the responses could be considered as negligible. The maximum DO increase that could be expected was about 0.4 mg/l in the vicinity of the Schuylkill River and about 0.3 mg/l for about three miles above and below this area. DO responses elsewhere in the estuary were all less than 0.3 mg/l.

5. The 50% DO saturation goal in Zone 3 was not met during June-July 1963 and August-October 1962 in most of the Zone. On the average, deficits from 50% saturation range from 0.5 mg/l at Pennsauken Creek to 3 mg/l at the Pennsylvania-Delaware State Line. There are many different programs of effluent modifications, any one of which will correct the deficits. Among these, a minimum cost program of effluent modifications was computed. The cost of this optimal program was two hundred eighty-two million dollars ($282,000,000). Due to the sparseness of available cost data and the neglect of esoteric alternatives (e.g. mechanical and diffusive aeration) this figure is, at best, only approximate. In those sections of Zone 3 in which effluent modifications were part of the optimal program, the resulting BOD removal ranged from 61% to 98%. Therefore, the effluent BOD standard in Zone 3, 35% removal, is inconsistent with the attainment of 50% DO saturation.

Review of Present Water Quality and Interstate Standards of the Delaware Estuary

Interim Report from the Technical Committee to the Policy Advisory Committee

September, 1963

1. Introduction

At the first meeting of the Delaware Estuary Study's Policy Advisory Committee on July 25, 1963, concern was expressed over the length of time which would elapse before completion of the Study and the development of a Comprehensive Water Quality Management Plan. The Policy Committee was also concerned over the present compliance and degree of effectiveness of the existing interstate standards for the Delaware River Basin, commonly known as the Incodel Standards.[1] The Committee then requested a short report which would indicate the present state of water quality of the estuary as well as the effect on quality of complete literal compliance with the Incodel standards. The final requirement was that an estimate should be made, on the basis of present knowledge, of what measures would have to be taken to improve the water quality. The report as given herein attempts to comply with these requests.

At a meeting of the Technical Committee on August 14, 1963, it was agreed that the report would essentially be a statement of factual information and would not attempt to interpret the results obtained in any detail. This implies that those aspects of the Interstate Standards which are qualitative in nature would not be analyzed. An analysis of

---

1. A copy of the Standards is attached herewith as Appendix 1 for ease of reference.

this type would have required the imposition of numerical limits which were not now a part of the present standards. The results as reported on herein are based on the available data coupled with several assumptions which were made as realistic as possible within the restrictions imposed by ease of computation and by the time allowed for completion of the analysis.

As is known by the members of the Policy Committee, the Delaware Estuary Study staff is now engaged in an extensive field investigation to obtain additional information so that the final analyses can be made as precisely and as accurately as possible.

The report first provides an estimate based on available data of the present water quality of the estuary. A discussion of the present degree of compliance with the standards is then given and the information obtained is used in an analysis of the effects of literal compliance with an 85% BOD removal in Zone II and a 35% BOD removal in Zone III. Finally, an analysis of what must be done to present loads to reach the 50% DO saturation goal for Zone III is given. Time did not permit an analysis of the additional quantitative standard for Zone II - that no discharge shall reduce the DO in the stream by more than 10%.

The report was prepared by the staff of the Delaware Estuary Comprehensive Study and was reviewed by the members of the Technical Committee. Pertinent comments, if any, made by the members of this Committee are given in Appendix 2. It is sincerely hoped that all who are concerned with the results as given here will accept them with the full realization that they are preliminary in nature and subject to future change. It is believed, however, that the results can serve as useful guidelines for the members of the Policy Committee in determining the effectiveness and usefulness of the present standards.

2. Estimates of Present Water Quality of the Delaware Estuary

The present water quality of the estuary can be summarized from the results of the weekly sampling program being carried out by the Study staff. Although a considerable amount of data has been and is being collected by other agencies, analyses of these data with the exception of some continuously recorded data from the U.S.G.S. - Phila. monitoring stations have not yet been carried out. All available sources of data will eventually be tapped and every attempt will be made to incorporate the results into a complete picture of the present water quality.

The stations occupied by the Delaware Estuary Comprehensive Study (DECS) are given in Table 1 and a map locating these stations is given in Figure 1. The stations being sampled at the present time cover approximately a 60 mile stretch of the estuary from the Delaware Memorial Bridge to Fieldsboro, N. J. Samples are collected once each week and at approximately the same time for every run. In this manner estimates of any tidal influences which are present and which affect a particular variable can be obtained.

Since the primary objective of this report is to assess the effects of the present quantitative interstate standards, major emphasis was placed on the dissolved oxygen regime of the Delaware. Table 2 summarizes the distribution of this variable as well as the distribution of the 5-day BOD. The DO values given in Table 2 were those used in the analysis of the 50% DO saturation goal of the Incodel standards, a discussion of which is given in the final section of the report. The results given in the Table indicate that at no place over the indicated

TABLE 1

LOCATION OF SAMPLING STATIONS
DELAWARE ESTUARY COMPREHENSIVE STUDY

Station No.	River Mile (approx.)*	Location
2	Mile 69.0	Delaware Memorial Highway Bridge - West Tower
3	Mile 79.1	At Marcus Hook, Pa., between Pier No. 1 of Sun Oil Co. and lighted markers on New Jersey shore
4	Mile 84.8	At Eddystone, Pa. in line with Buoy "1E" and end of dry dock on Pennsylvania shore
5	Mile 89.2	At Paulsboro, N. J. between Buoy Qk Fl "1F" and light tower on New Jersey shore
6	Mile 92.2	At Navy Yard between Pier No. 2 and ferry on New Jersey shore
7	Mile 98.4	At Wharton Street, Philadelphia, Pa. and Kaighns Point, Camden, N. J. between Pier No. 55 and the Camden Refrigerating and Terminals Co. building
8	Mile 100.5	At Benjamin Franklin Bridge between Pier No. 12N and a tank on New Jersey shore
9	Mile 102.2	At Lehigh Ave., Philadelphia, Pa., between Pier No. 18 and west bank of Petty Island
10	Mile 107.3	At Palmyra opposite Buoy C "11" approximately 500 yards upstream from Tacony-Palmyra Bridge
11	Mile 110.4	At Torresdale opposite Buoy 19
12	Mile 117.8	At Burlington-Bristol Bridge approximately 100 yards upstream
13	Mile 122.4	At Florence, N. J., opposite Buoy "64"
14	Mile 127.5	At Fieldsboro, N. J. between Buoy "85" and "84"

* Above mouth of Delaware Bay

FIGUREE No. 1

U. S. PUBLIC HEALTH SERVICE SAMPLING STATIONS ON THE DELAWARE RIVER

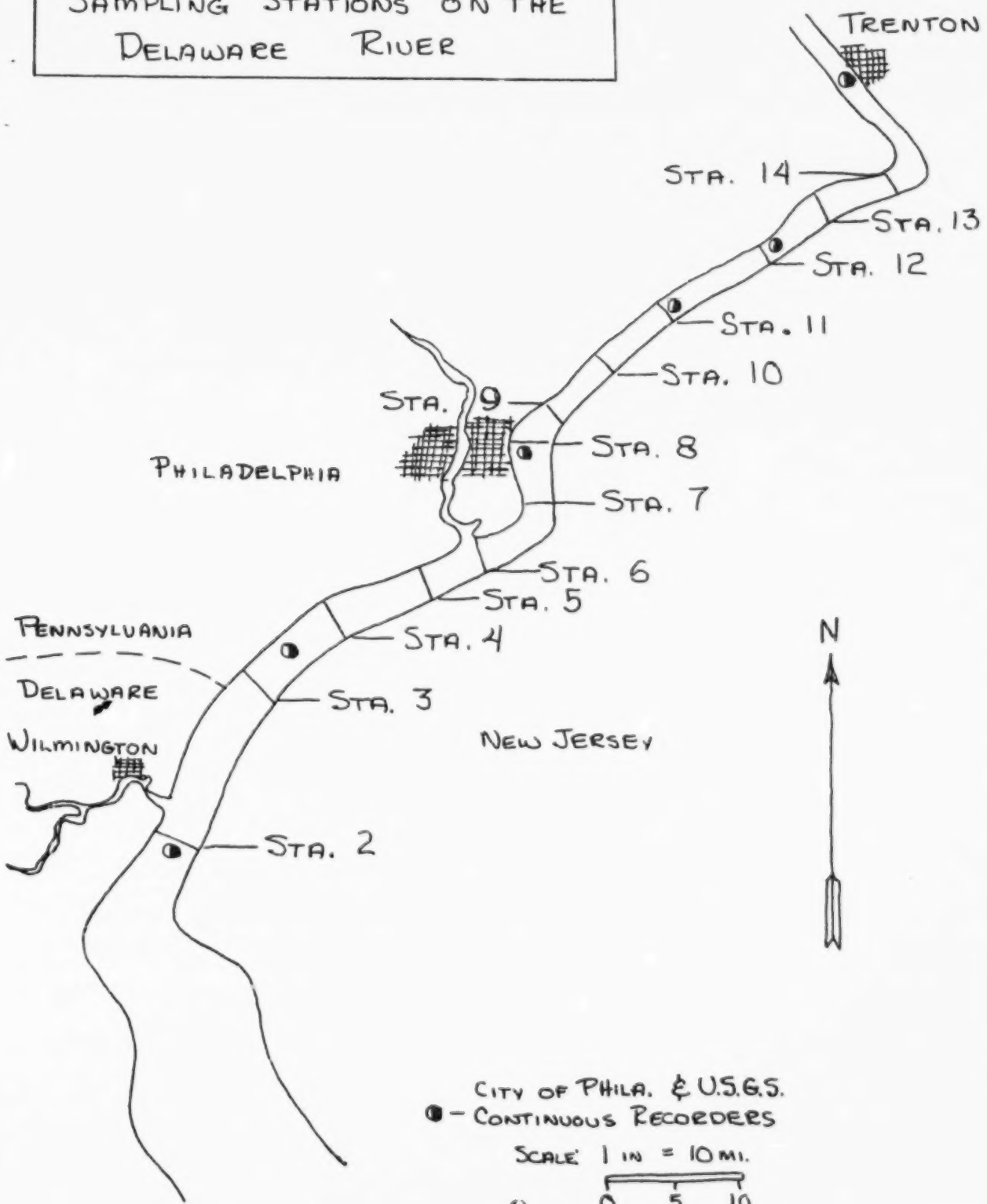

TABLE 2

WATER QUALITY REGIME USED IN ANALYSIS OF INTERSTATE STANDARDS*

Station No.	DO (mg/l)	BOD_5 (mg/l)
2	3.3	4.6
3	1.0	8.6
4	1.0	8.3
5	0.8	6.5
6	0.7	5.3
7	1.0	4.2
8	1.3	4.1
9	1.3	4.1
10	4.0	3.4
11	4.7	3.1
12	5.2	3.2
13	6.2	3.6
14	7.8	3.5

* Based on sampling runs by Delaware Estuary Study. Conditions are average over the period August-October 1962 and June-July 1963.

Reproduced from best available copy.

length of the estuary was the average DO at the saturation value although at Station #14, it almost attained this level. Since the values are means over about a five month period, considerable deviation from these values can be expected. On any given day poor oxygen conditions may occur over a considerable length of the stream. For example, on June 19, 1963, during flood tide conditions, the DO was below 2 mg/l for at least 40 miles of the river. Data from the continuously recording monitoring stations indicate complete exhaustion of the DO does occur over at least a 20 mile stretch of the estuary. The BOD values shown are generally consistent with the low DO values that were observed.

Table 3 presents some recent data on several other aspects of water quality. A definative longitudinal gradient in the pH and alkalinity can be noted with low values occurring at the lower end of the study area. Increased turbidity levels due to upstream dredging activities can also be seen from the results in the Table. Finally, increasing bacteriological counts can be noted from Station #13 to Station #6. No attempt will be made here to present a detailed analysis of the causes which could lead to the conditions shown.

3. Present Degree of Compliance with the Incodel Standards

In order to determine the present compliance with the existing interstate standards, discussions were held with representatives from Pennsylvania and New Jersey. It had previously been determined that the State of Delaware considered all the sources of waste within that state to be in compliance with the standards. Furthermore, since there are no quantitative BOD standards for Zone IV which lies entirely within the

Reproduced from best available copy.

TABLE 3

Some Recent Results on Water Quality

of the Delaware Estuary

(Average during June-July-August, 1963)

Sta #	pH	Alkalinity (mg/l)	NO_3 (mg/l)	NO_2 (mg/l)	Turbidity (mg/l Silica)	Geometric Means Coliforms (#/100ml)	Fecal Strep (#/100ml)
2	6.0	7	2.86	.61	47		
3	6.1	18	1.62	.60	28		
4	6.3	24	1.77	.50	23		
5	6.4	34	.69	.30	22		
6	6.5	35	.71	.24	16	240,000	1,500
7	6.5	35	1.11	.17	16	110,000	1,400
8	6.6	37	.84	.15	17	81,000	800
9	6.6	39	.82	.14	20	220,000	2,900
10	6.6	36	1.02	.06	34	260,000	480
11	6.7	34	1.20	.04	45	93,000	320
12	6.6	38	.80	.06	62	48,000	370
13	6.8	39	.54	.08	77	12,000	120
14	7.1	40	.39	.08	57	25,000	510

State of Delaware, it was not considered necessary to investigate the present degree of removal of wastes in the State of Delaware. The application of such results in the assessment of the effectiveness of the standards would have required a quantitative interpretation, where in fact no such numerical standard now exists.

The procedure followed in determining the compliance with standards in Pennsylvania and New Jersey was to review each municipal and industrial waste source in the light of available data. For many sources, this meant a relatively subjective decision that a secondary plant was removing at least 85% of the BOD and that a primary plant was removing at least 35% of the BOD. In some cases, data were available for municipalities that did indicate present per cent removals. While some of the municipalities that indicated removals less than standards were considered to be in compliance, a literal adherence was used in the analysis of the standards given in section 4 below.

For industrial installations, it was extremely difficult to determine degree of compliance with the quantitative BOD standards. For a complex industry, the concept of per cent removal has little or no meaning. Wastes can be generated and treated at many different locations within the plant. In the absence of any data to the contrary many plants were considered to be in administrative compliance although it is probable that following the completion of laboratory analyses of the larger industrial effluents, quantitative adherence to the standards may be found to be lacking.

For Pennsylvania the discussions indicated that administratively practically all waste sources were considered to be in compliance with the standards. The Pennsylvania Sugar Division of the National Sugar

Refining Co. which only recently has been found to be discharging some untreated industrial waste to the estuary is considered not in compliance until a more specific investigation can be made. The South West treatment plant of the City of Philadelphia while considered to be in compliance by virtue of its primary treatment facilities has a present degree of removal of about 30% and hence was one of the sources used to illustrate the effects of literal compliance with the 35% BOD removal standard for Zone III. The results of this analysis are discussed in section 4.

In New Jersey, the discussions followed a procedure similar to that indicated above. Several of the municipalities and industries that were not considered in compliance are under orders by the State Health Department to rectify the situation. Analagous to the South West plant of Philadelphia, the City of Camden's Main plant is considered to be in compliance, although it is estimated that it is presently removing about 30% of the influent BOD.

The results of the aforementioned discussions are summarized in Tables 4 and 5. Table 4 presents those discharges that were used to illustrate the effects on the DO of the estuary of literal compliance with an 85% BOD removal in Zone II and a 35% BOD removal in Zone III. The results of the computations are given in Section 4. Table 5 lists those sources that are suspected to be removing less than the standard. It is not necessary to include these sources explicitly in the following analysis since even the most crude estimates of waste discharges produced an insignificant dissolved oxygen response in the stream.

TABLE 4

Discharges Used to Illustrate the Effects of Literal Compliance with Quantitative Aspects of Existing Interstate Standards

Name	Location & Section No.	INCODEL Zone	Estimated Present Per Cent Removal (1)	Estimated Present # BOD_5/day Discharged	Estimated Additional BOD_5 (#/day) to be Removed for Literal Compliance (4)
John A. Roebling's Sons Division, Division of The Colorado Fuel & Iron Corp.	Roebling, N.J. (Burlington Co.) (Florence Twp.) #3	II	0(2)	1700	1450
Burlington City	Burlington Co. N.J. #4	II	55	950	640
Weyerhauser Co. Shipping Container Division	Delair, N. J. #10	III	0	2000	700
McAndrews & Forbes Co.	Camden, N. J. #13	III	0(2)	5000	1750
Camden City Main Plant	Camden, N. J. #13	III	30	37,500	6250
Penna. Sugar Div. National Sugar Refining Co.	Philadelphia,Pa. #13	III	0(3)	6000	2100
Philadelphia, Pa. S.W. Plant	Philadelphia,Pa. #15	III	30	108,000	7690

(1) Per cent removal of the present waste being discharged directly to stream.

(2) Discharges sanitary sewage to municipal sewer for subsequent treatment.

(3) Discharges sanitary sewage and some industrial waste to municipal sewer system for subsequent treatment.

(4) Removal of the amounts of BOD indicated would result in a numerical increase of at least 0.01 mg/l of dissolved oxygen in some section of the estuary. See Table 6 for the total increase in DO.

TABLE 5

Smaller Discharges that are Suspected

to be in Non-Compliance with Incodel Standards (1)

	Name & Location	Zone	Estimated Present Per Cent Removal (2)
1.	B. F. Goodrich Industrial Products Co., Riverside, N. J.	II	0(3)
2.	U. S. Steel Products Div. - U. S. Steel Corp., Delair, N.J.	III	0(4)
3.	Wood-Lynne, N.J.	III	20
4.	Brooklawn, N. J.	III	15
5.	The Rubberoid Company Gloucester City, N. J.	III	20
6.	Woodbury City, N. J.	III	10
7.	Paulsboro, N. J.	III	30

(1) Raising the per cent removal of these sources to that indicated by Incodel standards results in a DO response < 0.01 mg/l in all sections of the estuary.

(2) Per cent removal of present wastes being discharged directly to stream.

(3) Discharges sanitary wastes to municipal sewer system for subsequent treatment.

(4) Sanitary wastes discharged to septic tank.

4. Analysis of Effects of Literal Compliance with BOD Standards

The methodology used to determine the effects on DO of literal adherence to the BOD standards is embodied in a mathematical representation of the Delaware. It is beyond the scope of this report to present the technical details of this approach. As with many mathematical descriptions, there are several parameters that must be estimated. For the purposes of this report, the following parameters were used:

a) steady incoming flow of 3000 cfs at Trenton with other tributary streams to the estuary scaled accordingly,

b) diffusion coefficient equivalent to a 2 mi^2 / day as determined from dye studies in the Delaware model at Vicksburg, Miss.,

c) reaeration rate that is equal to the decay rate in the stream with a numerical value of 0.2/day,

d) conversion of 5-day BOD of effluents to ultimate BOD based on an effluent decay rate of 0.1/day.

While these assumptions are somewhat arbitrary, they are consistent with the physical situation. With reference to the equality of the reaeration rates and the decay rate in the stream, this assumption can be visualized as a base line from which statements can be deduced as to which direction the computed results would take if the numerical values of the coefficients were changed.

Using the parameters given above, a 1604 Control Data Corporation Computer located at New York University was used to generate a set of mathematical functions which form the basis for this analysis as well as the analysis given in Section 5. The mathematical model that is used in

these computations considers the estuary to be a series of connected finite sections starting at the head of tide at Trenton and continuing down the estuary to approximately Liston Point, Delaware. Figure 2 is a map of the estuary that shows the location of the various sections that were used in the mathematical representation.

The mathematical functions (or input-output relationships) that are generated by the computer essentially indicate the effect of a BOD discharge in one section on the dissolved oxygen concentration in any other section. For example, the functions indicate the effect of a discharge in say, section 9 on the dissolved oxygen in sections #1 through #30. Conversely, for a given section in the stream, the functions indicate the extent to which discharges in all other sections affect the DO in the given section. For example, for the DO in section #9, the functions indicate the effect on DO in that section due to discharges into sections #1 through #30. A copy of the computer output is available for inspection in the offices of the DECS.

With the input-output relationships determined, the problem then was to remove a certain amount of BOD load from various sections and to note the increases in DO response that would result. Hence, the reduction in BOD discharged as shown in the last column of Table 4 was used in the sections indicated and the resulting increases in DO were computed. The results of this computation are shown in Table 6.

An inspection of this Table indicates that in general the DO increases that were computed are relatively low and indeed are of a size that, considering the data that were available, may be considered as almost negligible. If the Table is read by columns, the results

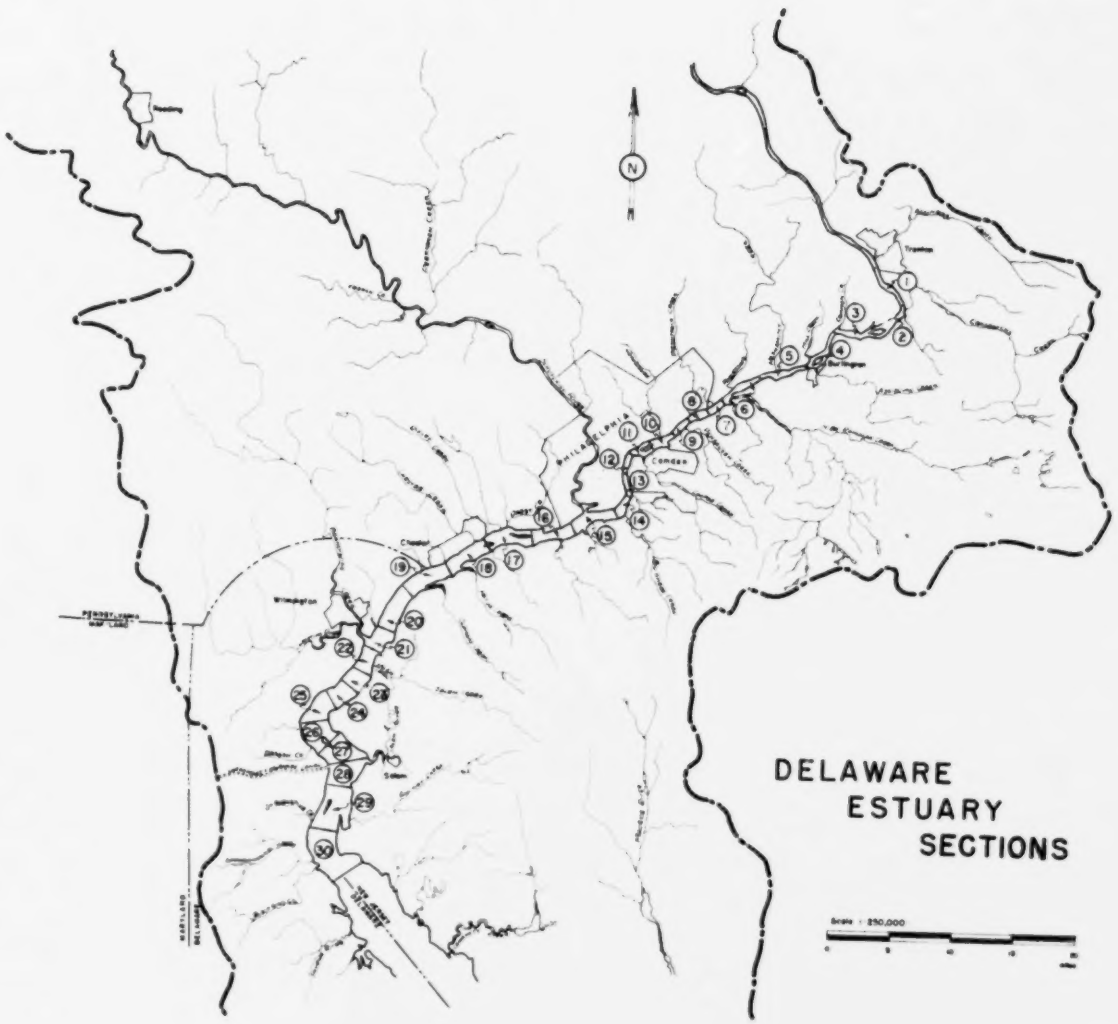

Figure 2

TABLE 6

Estimated DO (mg/l) Improvements Resulting from Literal Compliance with Quantitative BOD Interstate Standards*

DO Response in Section # / Input in Section #	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
#3	.05	.07	.06	.06	.05	.04	.04	.03	.02	.02	.01	.01							
#4		.02	.03	.03	.03	.02	.02	.02	.01	.01	.01								
#10							.01	.02	.02	.02	.02	.02	.01	.01	.01				
#13								.02	.04	.14	.25	.30	.25	.18	.11	.07	.04	.02	.01
#15										.02	.03	.08	.19	.16	.12	.08	.04	.02	.01
Total DO Response	.05	.09	.09	.09	.08	.06	.07	.09	.09	.21	.32	.41	.45	.35	.23	.15	.08	.04	.02

NOTE: Reading the Table across a row indicates the computed increase in DO due to removal of BOD in the indicated section. Reading the Table down a column indicates the computed DO responses for the section due to inputs in each of the rows.

* See also Table 4 for reductions in BOD_5 (#/day) discharged which were used to estimate the results in this tabulation.

indicate the computed increases in DO for the given section due to removal of BOD in the other sections. For example, reading down the column for Section #15, it is seen that the DO in this section would increase by .01 mg/l due to removal of BOD in Section #10, by .25 mg/l due to removal of BOD in Section #13 and by .19 mg/l due to removal of BOD in Section #15. If the Table is read across any one of the rows, the results indicate the computed increases in DO in each of the Sections shown due to removal of BOD in the given section. For example, reading across the row for removal of BOD in Section #13, it is seen that the DO would increase by .02 mg/l in Section #10, by .04 mg/l in Section #11, by .14 mg/l in Section #12, etc. Since the mathematical model that was used to obtain these values is a linear model, the total DO increase in each of the sections is given by the sum of the individual responses. The total is thus shown in the last line of the Table. The total increase of 0.45 mg/l is largest in Section #15. The responses decrease both upstream and downstream from this section. It is seen then that the removal of the BOD loads indicated in Table 4 from the estuarine system produces only a relatively small increase in the DO.

5. Analysis of 50% Saturation Goal in Zone III

The attached interstate Standards indicate that the intent of 35% BOD removal in Zone III is to restore the DO to fifty per cent of its saturation concentrations in the zone. In the analysis of effluent modifications that will reach this goal, a saturation DO of 8 mg/l was used; this corresponds to an average temperature of approximately 27°C. It is clear, from Table 7, that the goal of 4 mg/l did not prevail in much of Zone III. In particular, the reach from about Pennsauken Creek to the Pennsylvania-Delaware State Line (Sections #9 through #19 in Figure 2) had a mean DO of less than 4 mg/l.

TABLE 7

DEFICITS FOR 50% SATURATION IN ZONE 3

Section No.*	DO (mg/l)**	Deficit (mg/l) from 50% Saturation
19	1.0	3.0
18	1.0	3.0
17	1.0	3.0
16	0.8	3.2
15	0.7	3.3
14	1.0	3.0
13	1.1	2.9
12	1.3	2.7
11	1.8	2.2
10	2.7	1.3
9	3.5	0.5
8	4.0	None
7	4.4	None

* Figure 2, Delaware Estuary Sections, shows the sections' boundaries.

** Based on sampling runs by Delaware Estuary Study.
Conditions are average over the period August-October 1962 and June-July 1963.
Values for sections 7, 9, 10, 13 and 18 are by interpolation from adjacent sections.
See also Table 2.

The replacement of the deficits from 50% saturation (Table 7) can be accomplished in many alternative ways. There are, in other words, numerous programs of effluent modifications any one of which will bring about DO improvements at least sufficient to replace the deficits. Each of these programs has an associated cost and an unnecessarily expensive one is of no practical importance. Therefore, from among all the programs that would eliminate the deficits, an optimal or minimum cost program was sought.

An optimal solution was found with a mathematical procedure whose details are beyond the scope of this report. The estuary parameters that were used were the same as those specified in a) through d) in section 4 on page 7 of this report. The cost functions that were used were, at best, gross approximations. Their lack of precision was due primarily to the dearth of reliable data. An explanation of the estimation of the cost functions would be lengthy and will not be included in this report. The computations and graphs that were used, however, are available for inspection in the offices of the Delaware Estuary Comprehensive Study. It suffices to say that in the analysis, effluents in the same section were treated as a unit.

The minimum cost program is presented in Table 8, section by section, together with the estimated present BOD condition and those conditions computed under the optimal program. The procedure with which an optimal program was sought considered modifications of effluents in all sections from 1 to 30. Table 8 shows that it was found to be inefficient to take actions in sections 7, 8, 9, 11 and 14. Similarly, a program that modified effluents in any of sections 1 through 6

TABLE 8

Minimum Cost Attainment of 50% Saturation in Zone 3

Section No.	Present Discharge of BOD_5 (lb/day)	Present Mean* % Removal of BOD_5	BOD_5 Discharged to be Removed Under Optimal Program (lb/day)	Mean % Removal BOD_5* Under Optimal Program	Necessary Investment Under Optimal Program ($1,000,000)
19	73,800	33	63,000	90	56.7
18	57,500	53	38,400	84	38.7
17	41,500	74	28,200	92	27.5
16	22,600	35	21,800	98	23.0
15	147,600	46	45,100	61	40.8
14	87,500	48	None	-	None
13	69,700	35	42,000	74	44.9
12	None	-	None	-	None
11	8,200	45	None	-	None
10	66,800	73	61,800	98	50.2
9	600	73	None	-	None
8	500	75	None	-	None
7	200	84	None	-	None
	576,500		300,300		281.2

* In each section, computation of the mean per cent is weighted by size of effluent in BOD_5.

or 20 through 30 would have had a cost higher than that of the optimal program. These sections, therefore, did not enter into an optimal solution and were not noted in Table 8.

The estimated cost of the optimal program is $282,000,000 (two hundred eighty-two million dollars). It should be realized that this figure and the nature of the optimal program (Table 8) can be treated only as rough guides. The short time in which this report was prepared and the sparsity of data, particularly costs, require that use of the results be tempered with caution. Future results, it should be noted, may change noticeably if esoteric devices (mechanical aeration, diffusive aeration, storm water overflow retention basins, dredging to change section volumes, etc.) or new strategically located waste sources are included as alternatives in the search for an optimal program.

Inspection of Table 8 indicates that the removal of effluent BOD necessary to attain the 50 per cent saturation goal must exceed, by large amounts, the treatment specified in the standards.

APPENDIX 1

RECIPROCAL AGREEMENT FOR THE CORRECTION AND CONTROL OF POLLUTION OF THE WATERS OF THE INTERSTATE DELAWARE RIVER

As embodied in:

New Jersey	- Chapter 146, Laws of 1939
New York	- Chapter 600, Laws of 1939
Delaware	- Chapter 93, Laws of 1941
Pennsylvania	- Act No. 123, April 19, 1945

Article I

Each of the signatory States pledges to each of the other signatory States faithful cooperation in the control of future pollution and in the correction of existing pollution of the waters of the interstate Delaware river and its west branch from the New York - Pennsylvania boundary line down to the Atlantic ocean. In order to effect such objects, each of the States agrees to enact adequate legislation, if necessary, to enable each such State so to require the treatment of sewage, industrial waste or other artificial polluting matter as to place and maintain the waters of the aforesaid interstate Delaware river, and of the tributaries thereof just above the confluence with the Delaware river, in the clean and sanitary condition required by the provisions of this agreement. Furthermore, each such State agrees so to enforce the provisions of these requirements, and other supplementary applicable legislation, if any, as to bring about the attainment of the objectives of pollution control and correction in accordance with such reasonable and effective programs as may be determined from time to time by the States in the manner prescribed herein.

Article II

It is recognized by the signatory States that due to such variable factors as location, size, character, and flow, and of the many varied uses of the waters of the interstate Delaware river and its aforesaid west branch, such as water supply, recreation, navigation, industrial developments, maintenance of fish life, shellfish culture, agriculture, and other purposes, that no single standard of sewage and waste treatment and of quality of receiving waters is practical for all parts of the river. Therefore, in order to apply minimum requirements for the attainment of correction and control of pollution which will be appropriate to the varied factors including the existing and potential quality and uses of the waters, the interstate Delaware river is hereby divided into four zones, to wit:

Zone I: Zone one is that part of the Delaware river and its west branch extending from the New York - Pennsylvania boundary line to the head of tidewater at Trenton, New Jersey, and Morrisville, Pennsylvania.

The drainage basin contributary to this zone, excepting part of the Lehigh River Basin, is relatively sparsely inhabited and contains few sewered communities and relatively few industrial establishments producing waste water. The streams draining this area being, in general, relatively clean and of high elevation are well adapted as sources of public water supplies, after treatment or purification.

The principal uses of the waters of the Delaware river in Zone one are expected to be for water supply after such treatment or purification as may be necessary, and for recreation, bathing, maintenance of fish and aquatic life, agriculture, and for other related purposes.

Zone II: Zone two is that part of the Delaware river extending from the head of tidewater at Trenton, New Jersey, and Morrisville, Pennsylvania, to a line drawn perpendicular to the channel of the Delaware river from the mouth of Pennypack creek in Philadelphia, Pennsylvania, to the corresponding point on the New Jersey shore.

The drainage basin contributary to this zone is somewhat more densely populated than that of Zone one, and it contains more sewered communities and industrial establishments.

The principal uses of the waters of the Delaware river in Zone two are expected to be for water supply, after treatment or purification, and for recreation, navigation, maintenance of fish and aquatic life, agricultural, industrial and other purposes.

Zone III: Zone three is that part of the Delaware river extending from the aforesaid line connecting the mouth of Pennypack creek in Philadelphia and the corresponding point in New Jersey to the Pennsylvania-Delaware boundary line.

The drainage basin contributary to this zone contains populous metropolitan areas including Philadelphia, Pennsylvania, and Camden, New Jersey.

The principal uses of the waters of the Delaware river in Zone three are expected to be for navigation, industrial water supply, and other purposes.

The water in this zone, however, should be of such sanitary quality that it will not be unfit for use as sources of water supply, will not be harmful to fish life, and will not adversely affect the quality of the waters of the tidal tributaries.

Zone IV: Zone four is that part of the Delaware river extending from the Pennsylvania - Delaware boundary line to the Atlantic ocean.

The principal uses of the waters of the Delaware river in Zone four are expected to be for navigation, industrial water supply, commercial fishing, shellfish culture, recreation and other purposes.

Reproduced from best available copy.

In order to attain conditions of cleanliness and sanitation of the waters of the Delaware river which will be consistent with the appropriate existing and future quality and uses of such waters, the following minimum requirements shall apply to the several zones herein provided. It is the purpose and intent of such requirements to apply to artificial (not natural) causes of pollution.

Article III

In order to put and maintain the waters of the interstate Delaware river and its west branch as aforesaid, in a clean and sanitary condition, no sewage, industrial wastes or other polluting matter shall be discharged into, or be permitted to flow or fall into, or be placed in any respective zone of the interstate Delaware river as herein established, unless such sewage, industrial waste or other artificial polluting matter shall first have been so treated as to produce an effluent which will meet the following minimum requirements:

Zone 1: (1) Such effluent shall be free of noticeable floating solids, color, oil, grease, or sleek, and practically free of suspended solids.

(2) Such effluent shall be sufficiently free of turbidity that it will not cause noticeable turbidity in the water of the Delaware river.

(3) Such effluent shall show a reduction of organic substances of at least eighty-five per centum (85%) as measured by the bio-chemical oxygen demand, and furthermore, such effluent in no case shall exceed a biochemical oxygen demand of fifty (50) parts per million, and furthermore, the discharge of such effluent, after dispersion in the water of the river, shall not cause a reduction of the dissolved oxygen content of such water of more than five per centum (5%). The aforesaid reduction in dissolved oxygen content shall be determined by the average results obtained from dissolved oxygen tests made upon samples collected on not less than six (6) consecutive days from points in the river above and below the point or points of effluent discharge.

(4) Such effluent shall be of such quality that the most probable number of organisms of the Coli Aerogenes group shall not exceed one (1) per milliliter in more than ten per centum (10%) of the samples of sewage effluent tested by the confirmed test; and provided, further, that no single sample shall contain more than one hundred (100) organisms of the Coli Aerogenes group in one (1) milliliter.

(5) Such effluent shall be sufficiently free of acids, alkalis, and other toxic or deleterious substances, that it will not create a menace to the public health through the use of the waters of the Delaware river for public water supplies, for recreation, bathing, agriculture and other purposes; not be inimical to fish, animal or aquatic life.

(6) Such effluent shall be free of offensive odors and also be free of substances capable of producing offensive tastes and odors in public water supplies derived from the Delaware river at any place above or below the discharge of such effluent.

Reproduced from best available copy.

Zone 2: (1) Such effluent shall be free of noticeable floating solids, color, oil or grease, and practically free of both suspended solids and sleek.

(2) Such effluent shall be sufficiently free of turbidity that it will not cause noticeable turbidity in the water of the Delaware river.

(3) Such effluent shall show a reduction of organic substance of at least eighty-five (85) per centum as measured by the bio-chemical oxygen demand, and furthermore, such effluent in no case shall exceed a bio-chemical oxygen demand of one hundred (100) parts per million, and furthermore, the discharge of such effluent, after dispersion in the water of the river, shall not cause a reduction of the dissolved oxygen content of such water of more than ten (10) per centum. The aforesaid reduction in dissolved oxygen content shall be determined by the average results obtained by dissolved oxygen tests made upon samples collected on not less than six (6) consecutive days from points in the river above and below the point or points of effluent discharge.

(4) Such effluent shall be of such quality that the most probable number of organisms of the Coli Aerogenes group shall not exceed one (1) per milliliter in more than twenty-five (25) per centum of the samples of sewage effluent tested by the confirmed test; and provided, further, that no single sample shall contain more than one hundred (100) organisms of the Coli Aerogenes group in one (1) milliliter.

(5) Such effluent shall be sufficiently free of acids, alkalis, and other toxic or deleterious substances, that it will not create a menace to the public health through the use of the water of the Delaware river for public water supplies, for recreation, industrial and other purposes; nor be inimical to fish, animal or aquatic life.

(6) Such effluent shall be free of offensive odors and also be free of substances capable of producing offensive tastes or odors in public water supplies derived from the Delaware river at any place below the discharge of such effluent.

Zone 3: (1) Such effluent shall be free of noticeable floating, solids, oil or grease, and substantially free of both suspended solids and sleek.

(2) Such effluent shall be sufficiently free of turbidity that it will not cause substantial turbidity in the water of the Delaware river after dispersion in the water of the river.

(3) Such effluent shall show a reduction of at least fifty-five (55) per centum of the total suspended solids and a reduction of not less than thirty-five (35) per centum of the bio-chemical demand. (It is the intent of this requirement to restore the dissolved oxygen content of the river water in this zone to at least fifty (50) per centum saturation. To accomplish this it may be necessary in the case of certain wastes to obtain reductions greater than those required under this item.)

(4) Such effluent, if it be discharged within two miles of a public water works intake or within prejudicial influence thereof, shall at all times be effectively treated with a germicide.

(5) Such effluent shall be sufficiently free of acids, alkalis, and other toxic or deleterious substances, that it will not create a menace to the public health through the use of the waters of the Delaware river for public water supplies, or render such waters unfit for industrial and other purposes; or cause the water of the Delaware river to be harmful to fish life.

(6) Such effluent shall be practically free of substances capable of producing offensive tastes or odors in public water supplies derived from the Delaware river.

Zone 4: (1) Such effluent shall be free of noticeable floating solids, oil, or grease, and substantially free of both suspended solids and sleek.

(2) Such effluent shall be sufficiently free of turbidity that it will not cause substantial turbidity in the waters of the Delaware river after dispersion in the water of the river.

(3) Such effluent shall show a reduction of at least fifty-five (55) per centum of the total suspended solids and shall be subject to such further treatment as may be needed to prevent a nuisance.

(4) Such effluent, if it be discharged within prejudicial influence of a public water works intake, or of recreational areas, or of shellfish grounds, shall at all times be effectively treated with a germicide, except that in the case of recreational area influence, such treatment need not be provided during the period from October fifteenth to May fifteenth of each year.

(5) Such effluent shall be sufficiently free of acids, alkalis, and other toxic or deleterious substances that it will not create a menace to the public health through the use of the waters of the Delaware river for public water supplies or render such waters unfit for commercial fishing, shellfish culture, recreational, industrial, or other purposes.

(6) Such effluent shall be practically free of substances capable of producing offensive tastes or odors in public water supplies derived from the Delaware river.

It is further recognized by the signatory States that the quality of the waters of the intrastate tributaries of the Delaware river and its aforesaid west branch are of interstate concern at their points of confluence with the Delaware river and its west branch. Therefore, it is also agreed that sewage, industrial waste or other artificial polluting matter discharged into, or permitted to flow or to fall into, or be placed in any intrastate tributary of the aforesaid Delaware river shall be treated to that degree, if any, necessary to maintain the waters of such intrastate tributary immediately above its confluence with the aforesaid Delaware river in a condition at least equal to the clean and sanitary condition of the waters of the Delaware river immediately above the confluence of such tributary.

Analyses and tests regarding the minimum requirements herein prescribed, shall be determined in accordance with the provisions contained in the American Public Health Association's latest edition on "Standard Methods for the Examination of Water and Sewage."

The aforesaid requirements as to treatment of sewage, industrial wastes or other artificial polluting matter and as to the sanitary quality of receiving waters are minima. It is the intent and purpose of these requirements to accomplish reasonable and adequate control and correction of pollution. Due to the many variable factors involved, however, and to the impossibility of forecasting future developments with certainty, it may be necessary in the future to impose additional requirements, particularly in Zones two and three.

The minima herein prescribed therefore shall be considered the first steps toward attaining the objectives sought, and if necessary may be required to be supplemented in the case that the general application of such minimum requirements does not adequately improve and maintain the sanitary quality of the waters of the Delaware river.

APPENDIX 2

C O P Y

WATER POLLUTION COMMISSION
State of Delaware
Dover, Delaware

C O P Y

September 13, 1963

Dr. Robert V. Thomann
Technical Director
Delaware Estuary Study
321 Chestnut Street
Philadelphia, Pennsylvania

Dear Dr. Thomann:

Thank you very much for the draft copy of the report to the policy committee. I have only one comment to make. As the cost functions are gross approximations, the price tag to increase the quality in Zone III should be omitted from the report. I was under the impression that there would be no attempt to include price tags at this stage of study.

Sincerely yours,

/s/ N. C. Vasuki
N. C. Vasuki
Assistant Engineer

NCV:ib

C O P Y

STATE OF NEW JERSEY
DEPARTMENT OF HEALTH
BOX 1540, TRENTON 25

C O P Y

September 16, 1963

Dr. Robert V. Thomann, Technical Director
Delaware Estuary Study
U. S. Public Health Service
321 Chestnut Street
Philadelphia, Pennsylvania 19106

Dear Dr. Thomann:

Re: Draft of Interim Report to Policy Committee

I have reviewed the draft of the Report and offer the following comments as constructive criticisms:

SUMMARY, SECOND PAGE:

Last sentence of Paragraph #2 is ambiguous and not clear.

TABLE 4:

The arithmetic is not clear with respect to Burlington #4, Camden #13 and Philadelphia #15. Also, the B.O.D. poundage data for Camden do not compare with the previous estimate of 37,500 lbs. per day, which was believed to be a realistic figure.

TABLE 5, ITEMS #2 and #4:

Brynwood Estates and Kingston Estates both have secondary treatment. Although both plants are recognized as overloaded and deliver unsatisfactory effluents by New Jersey standards, our most recent sampling data indicate the effluents do meet the more lax INCODEL standards for Zone III, 35% removal.

It is suggested that instead of the above items you might substitute the following municipal plants, all in Zone III, which have primary treatment for domestic sewage:

Brooklawn, 210,000 G.P.D., with 15% B.O.D. removal.

Paulsboro, 610,000 G.P.D., with 30% B.O.D. removal.

Wood-Lynne, 320,000 G.P.D., with 20% B.O.D. removal.

In general, the report is very well pointed and straightforward in form. More emphasis and discussion might be placed on the highly inadequate standards now existing for Zone III and the need for their upward revision. Also, the question might well be raised at this time: "Is the 50% D.O. saturation goal compatible with the needs of the Estuary?" I think we will eventually come to agree that we need a higher goal, and therefore a whole new set of effluent standards.

Yours very truly,

/s/ Harry H. Hughes
Harry H. Hughes
Principal Public Health Engineer

6E3:G7

C
O
P
Y

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF HEALTH
P. O. BOX 90
HARRISBURG

C
O
P
Y

September 20, 1963

Mr. Robert V. Thomann, Technical Director
Delaware Estuary Study
Department of Health, Education & Welfare
321 Chestnut Street
Philadelphia, Pennsylvania 19106

Dear Mr. Thomann:

We have reviewed your interim report, "Review of Present Water Quality and Interstate Standards of the Delaware Estuary".

The assumptions made appear reasonable as does the procedure followed in answering the questions posed by the Policy Advisory Committee. We recognize that certain short-cuts were necessary to overcome the short time limit and the scarcity of data in some areas.

The statement on Page 6 and Table V concerning the Borough of Trainer is not correct. Only a portion of Trainer Borough is sewered and the collected sewage is treated in the sewage treatment works of the City of Chester. The balance of the borough is not sewered.

The statement on Table IV concerning Pennsylvania Sugar Division of National Sugar Refining Company indicates that the company does not provide treatment for its industrial wastes. Our records indicate that many years ago all industrial wastes and sewage from this establishment were being discharged directly to the Delaware River. The company later constructed facilities to discharge its sanitary sewage to the City of Philadelphia sewer system and also to discharge industrial wastes having a high BOD to the city sewers. Investigation will be needed to determine the present degree of compliance. Our main objection is that the "0" shown under the percent removal column gives a wrong impression.

Although you have presented one solution to the Policy Advisory Committee's question, we feel that the analyses of the 50 percent saturation goal for Zone 3 gives a rather misleading picture of the pollution abatement steps necessary to attain this goal, since the analysis applies the cost of necessary treatment facilities to Zone 3 only.

C
O
P
Y

C
O
P
Y

An analysis which applies the cost of necessary treatment facilities to the entire estuary would give the committee a much more realistic picture of the necessary treatment and associated costs.

Very truly yours,

/s/ Ralph L. Rhodes
Ralph L. Rhodes
Assistant Chief
Stream Quality Section